

# SUSTAINABLE BUILDING MATERIALS IN FRENCH POLYNESIA

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# PRESENTATION SUMMARY

- Context/Background
- Original Project Statement & Goals
- New Project Statement & Goals
- Connection to Sustainability
- Approach
- Trip to French Polynesia
- Results
- Next Steps

Berkeley Gump Station, Moorea

SUSTAINABLE BUILDING MATERIALS IN FRENCH POLYNESIA



# CONTEXT & BACKGROUND

## *What & Why:*

- Series of cyclones devastated the islands
- Government subsidized program to rebuild
- Hundreds of emergency, hurricane resistant, kit homes built
- High commercial demand remains
- However, models trap & intensify heat



## *Previous Group Project:*

- Modeled climatic performance
- Assisted in modeling ventilation improvements
- Created bioclimatic design to meet requirements:
  - Hurricane resistant
  - Durable
  - Comfortable
  - Affordable
  - Modern



## ORIGINAL PROJECT STATEMENT

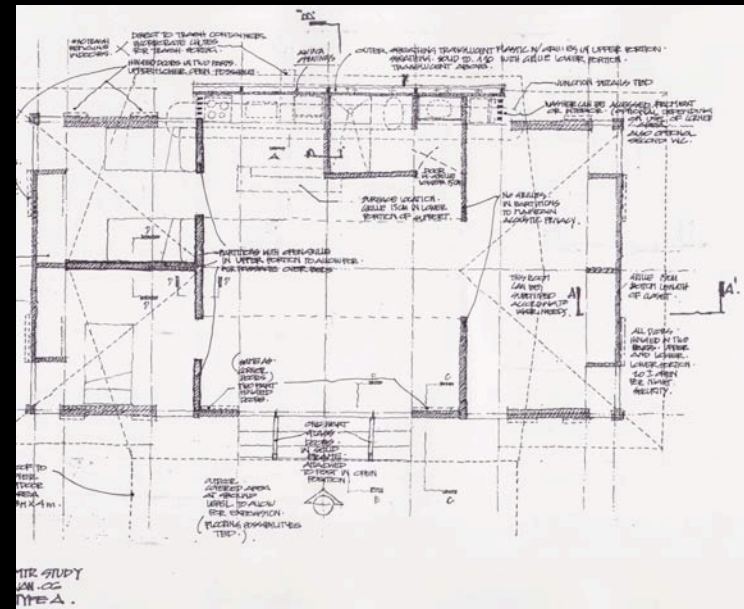
## Original Project Statement:

- Find local sustainable materials for existing kit house in French Polynesia



## Original Goals:

- Gather information about local resources & recyclable materials
- Create designs for building materials from these resources
- Design a basic business plan to locally produce the new materials



# REVISED PROJECT STATEMENT & GOALS



## Revised Project Statement:

To create sustainable livelihoods by finding a holistic solution to connect wastes with needs, reduce the embodied energy content and associated greenhouse gas emissions from material manufacture and construction.

## Summary of Revised Goals:

- ID appropriate technologies to replace imported wood panels with local manufacturing from local waste products
- Develop schematic feasibility plan
- Quantify environmental factors
- Cost analysis
- Package information to attract project champions
- Package information to support next group



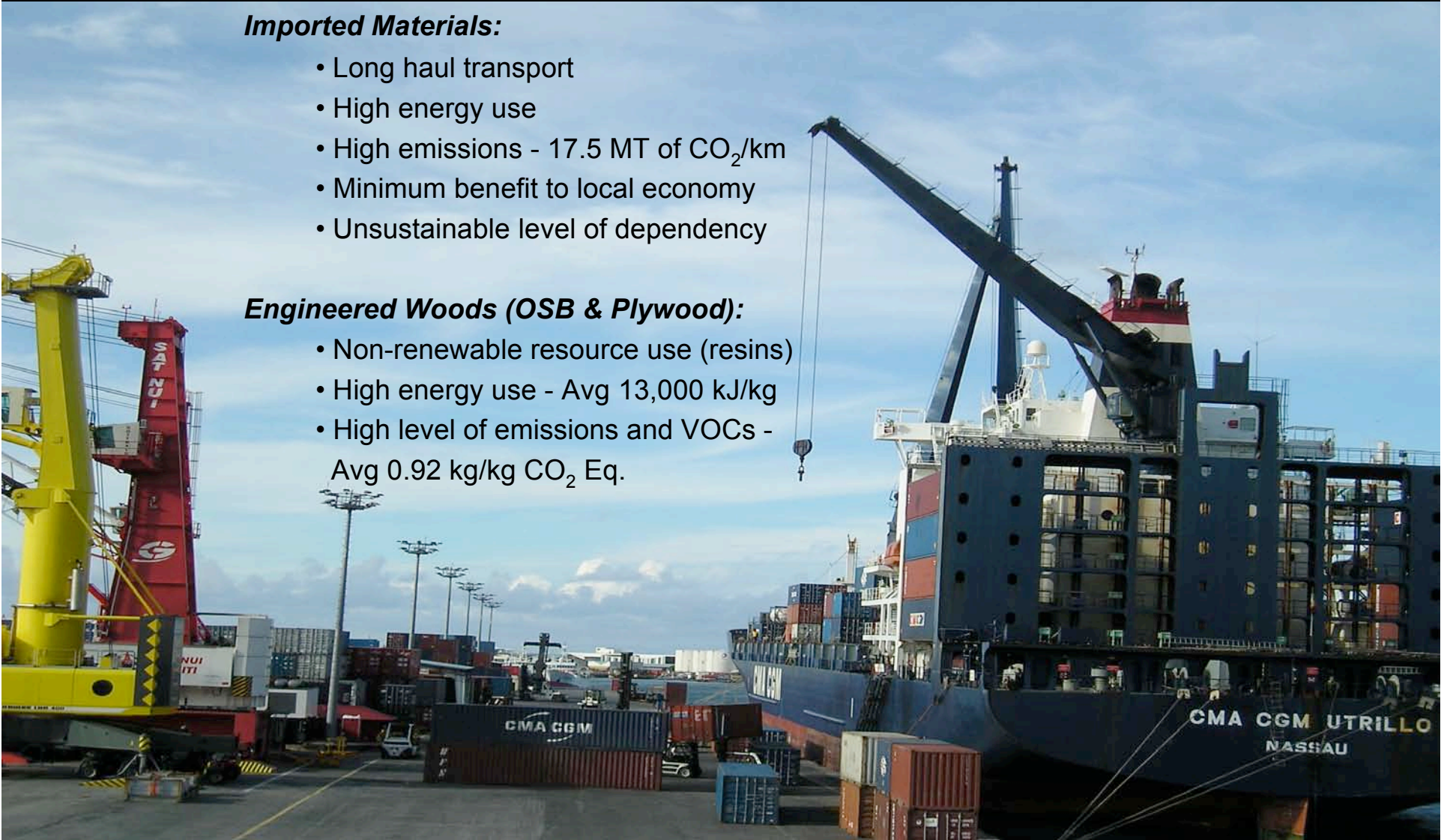
# CONNECTION TO SUSTAINABILITY

## ***Imported Materials:***

- Long haul transport
- High energy use
- High emissions - 17.5 MT of CO<sub>2</sub>/km
- Minimum benefit to local economy
- Unsustainable level of dependency

## ***Engineered Woods (OSB & Plywood):***

- Non-renewable resource use (resins)
- High energy use - Avg 13,000 kJ/kg
- High level of emissions and VOCs - Avg 0.92 kg/kg CO<sub>2</sub> Eq.



# CONNECTION TO SUSTAINABILITY

## **Local Materials:**

Create localized sustainable business

- Increases earning potential
- Reduce rural to urban migration
- Maintains community
- Self-sufficiency

Use agricultural waste product

- Adds additional value to crop
- Reduces waste burning & GHG emissions



Husk (coir/pith)

Skin

Shell

Copra



# PROJECT APPROACH

## Identify Needs

- Element Matrix
- Literature review of sustainable materials
- Interviews

## Identify Available Resources

- Materials Matrix
- Trip to French Polynesia

## Match Resources to Needs

- Trip to French Polynesia
  - Interviews
- Modify project scope
- Validation

ASSESS

PROGRESS



# MATERIALS MATRIX

Materials Summaries – Information to date: March 19, 2007

Material/Product	DESCRIPTION	Availability
Coir	Agricultural waste product from the palm/coconut/copra industry. Coir is the husk material between the coconut inner shell and outer shell. It contains both fibers and lignin. <b>POSITIVES:</b> Waste-product, good tensile element in composite matrix <b>NEGATIVES:</b> Waxy surface may require pre-treatment; can imbibe h2o	Possibly abundant
Resin	A binder, herein meaning a natural binder obtained from the lignin portion of the coir. <b>POSITIVES:</b> Waste-product, good natural adhesive, (low/zero toxicity?) <b>NEGATIVES:</b>	Possibly abundant
PAcement	Palm Ash (PA) is a waste-product from the palm oil industry. It is pozzolanic binder, meaning it can replace significant portions (+/-50%?) of portland cement (PC). PAcement herein means a cement mortar matrix consisting of local sand and maximum workable portions of PA + PC+ water. Other fine aggregates from recycled materials (crushed glass etc) are also possible inclusions. <b>POSITIVES:</b> Waste-product. Less permeable more durable mortar. <b>NEGATIVES:</b> possibly increased set time at high proportions	Possibly abundant
Coir/resin panel	Panel material made from coir and resin. The coir fiber and lignin is heated and rolled together forming sheet material. We are looking for more information to see if a OSB (or plywood) type panel exists. <b>POSITIVES:</b> Known entity - currently being implemented with a pilot plant in the Phillipines. Scale of production seems applicable. Good structural properties for strength (similar too but stronger than MDF) <b>NEGATIVES:</b> Like MDF this is a relatively brittle material and cannot be nailed through. This complicates connection detailing. Panels would have to be screwed to supports through pre-drilled holes.	Must establish local manufacturing
Coir/PAcement panel	Panel material made from coir and PAcement. The coir fiber would be incorporated as fibrous reinforcement in a composite panel. <b>POSITIVES:</b> Similar to current imported product. Connection detailing may be modeled after current product. <b>NEGATIVES:</b> Less information currently found. No known manufacturing to model after.	Must establish local manufacturing
<b>More info and products needed for all materials listed below</b>		
Recycled Glass	Local Household and Commercial Waste – sorting and availability unknown. Possible uses range from a crushed material (fine aggregate) to a finished tile product.	Possibly abundant
Recycled Paper	Local Household and Commercial Waste – sorting and availability unknown. Area of interest is to create interior wall panels (similar to Homasote). This is a soft material with sufficient stiffness for partitions. Possibly issues with sensitivity to humidity (swelling).	Possibly abundant
Recycled Plastic	Local Household and Commercial Waste – sorting and availability unknown. Recycled plastics (RP) can take many forms. One area of interest is to use RP in a molten state as binder in a coir fiber panel. Also graded shredded bottles can be used as aggregate replacement in concrete.	Possibly abundant



# RECONNAISSANCE TRIP: French Polynesia



## Materials Investigated:

- Recycled Plastics & Paper
- Animal Waste
- Palm ash
- Local woods
- Coir (coconut husk)



# TRIP FINDINGS

OPH (Office of Polynesian Housing):

- Consumer choice of 2 alternatives
  - Concrete masonry unit
  - Wood



Findings:

- Sustainability not tied to OPH
- Expand materials to all sectors of construction



# TRIP FINDINGS

## *Animal Waste:*

- Limited sources
- Lack of local interest



## *Household waste/ recyclables:*

- Recycling in beginning phase
- Insufficient quantities
- Diverse interests
- No cost for exportation



# TRIP FINDINGS



## *Ash from oil production:*

- Oil produced in Papeete
- Uses electricity for extraction
- No ash produced

## *Local Woods:*

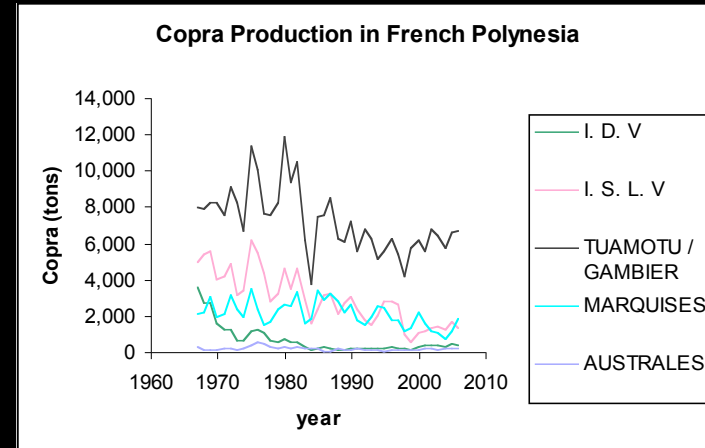
- Caribbean Pine
- Coconut Wood
- Limited supply
- Workability
- Finish material only



# TRIP FINDINGS

## ***Coconut based materials:***

- Significant livelihood in outer islands
- Majority of production exists on Tahaa & Tuamotu Islands
- Minimal production on larger islands (Moorea, Tahiti)
- Highly subsidized industry (100 vs. 20 francs)



# BEST TECHNOLOGY: COIR BOARD

## Pros

- No added binders
- Efficient resource use
- Panels and Molded shapes
- Structural and non structural grades
- Simple and proven production process
- Technology transfer planned
- Long history of study
- Abundant resource



## Concerns

- Connection details?
- Finishes/long term durability?
- Availability of source material
- Sufficient market to justify manufacturing



# ALTERNATE ENERGY PLAN

- Compare production of Coir Board using coconut oil versus diesel

Data (average values):  
 Density of coconut oil = 0.925 kg/L  
 Density of petroleum diesel = 0.885 kg/L  
 Fuel value of coconut oil = 42 MJ/kg  
 Fuel value of petroleum diesel = 45 MJ/kg  
 Standard 15 HP grinding equipment processes about 225kg of material per hour, extrapolating up, assume 180 HP capacity = 2,700 kg/hr  
Energy Conversions:  
 1 horse power = 0.746 KW  
 1 KWh = 0.2778 MJ

5 average coconuts

1 kg copra

3.5 kg husk (coir)

0.70 kg coconut oil as  
0.76L coconut oil

Small-Medium scale plant uses 155 million coconuts; 20,500 tonnes husk to produce 20,000 tonnes of product = 780,000 panels 0.019m<sup>3</sup> (at US standard construction size of 4'x8'x1/4"). Total product = 2,264 m<sup>2</sup> of panel

Estimated total process energy 150 KWh/tonne of husk. Total plant requirement = 3,078 MWh/yr

29.4 MJ = 8.17 KWh  
 Or 10.75 KWh/L  
 Or 10.75 KWh/L

163 kg husk pressed/kg of copra  
 489 kg husk processed/kg copra

41,900 kg copra to fuel  
entire operation

Estimated 2.3 Million tonnes of CO<sub>2</sub> emissions from processing are avoided through the use of coconut oil. Additional emissions averted from replacing imported engineered wood and transportation of imports including fuel.



# INTER-ISLAND TRANSPORTATION

## SCHEMES:

### 1) New routes

Proposed Routes within Island Groups Producing > 100,000 kg of copra						
Route	Island Group	Husk (MT)	Distance (km)	Husk/Distance (MT/ km)	Freight CO <sub>2</sub> (MT)	CO <sub>2</sub> Burning Husks (MT)
1N	IDV/ ISLV	5,018	523	<b>9.595</b>	46	6.40
2N	Marquises	6,179	3,258	1.897	352	7.88
3N	Tuamotu Center	2,819	2,092	1.347	103	3.60
4N	Tuamotu East	4,539	3,379	1.343	268	5.79
5N	Tuamotu West	6,974	1,529	<b>4.561</b>	187	8.90
6N	Tuamotu North-East	2,326	2,574	0.904	105	2.97

(N- new route)



# INTER-ISLAND TRANSPORTATION

## SCHEMES

### 2) Existing routes

Existing Ferry Routes in French Polynesia					
Route	Husk (MT)	Distance (km)	Husk/Distance (MT/ km)	Freight CO <sub>2</sub> (MT)	CO <sub>2</sub> Burning Husks (MT)
1E	7,887	3,500	<b>2.253</b>	483	10.06
2E	1,341	925	1.450	22	1.71
3E	1,800	1,126	1.599	35	2.30
4E	1,285	1,448	0.887	33	1.64
5E	2,676	1,126	<b>2.377</b>	53	3.41
6E	10,195	4,143	<b>2.461</b>	739	13.01
7E	7,482	3,821	1.958	500	9.55
8E	2,367	3,138	0.754	130	3.02
9E	1,391	925	1.504	23	1.77
10E	1,285	1,448	0.887	33	1.64
11E	2,675	1,006	<b>2.659</b>	47	3.41
12E	10,752	4,787	<b>2.246</b>	901	13.72
13E	4,340	3,990	1.088	303	5.54

(E- existing route)



# ENVIRONMENTAL COMPARISON

## Lifecycle Emissions of Current Products vs. Coir Board

Material	Production CO <sub>2</sub> (MT)	Import CO <sub>2</sub> (MT)	Local Distribution CO <sub>2</sub> (MT)	Husk Burning CO <sub>2</sub> (MT)	Total CO <sub>2</sub> (MT)
OSB/Plywood	18,400	2,625	0	27	21,052
Coir Board, diesel	2,400	0	1,640	0	4,040
Coir Board, coconut oil	0	0	1,640	0	<b>1,640</b>



# COST COMPARISON

## Breakeven Scenario

Power Supply	Initial Investment (\$)	Operating Cost (OH, Labor, Materials) (\$)	Energy Cost (\$)	Cost per Panel (\$)
Grid Connection	2,000,000	210,000	1,230,000	4.60
Generator	2,000,000	210,000	307,800	3.36

## 25% Return Scenario

Power Supply	Initial Investment (\$)	Operating Cost (all) (\$)	Revenue (\$)	Cost per Panel (\$)
Grid Connection	2,000,000	1,440,000	500,000	5.25
Generator	2,000,000	517,800	500,000	4.02

## Overall Cost Comparison

Scenario	Plywood/OSB	Coir Board, grid connected	Coir Board, generator
Breakeven	\$6.00/panel	\$4.60/panel	\$3.36/panel
25% Return	\$6.00/panel	\$5.25/panel	\$4.02/panel



# ACHIEVED GOALS

TASK	TYPE
ID appropriate technologies	Minimum
Prepare support package <ul style="list-style-type: none"><li>Reviewed material to support next group</li></ul>	Minimum
Quantify environmental indicators <ul style="list-style-type: none"><li>Compare current and proposed systems</li></ul>	Optimum
Cost analysis	Optimum
Develop schematic feasibility plans: <ul style="list-style-type: none"><li>One island vs. multi island plans, alt. energy plan</li></ul>	Minimum/ Optimum
Outreach <ul style="list-style-type: none"><li>Contact possible champions and sustainable partnerships</li></ul>	Minimum/ Optimum



# NEXT STEPS

TASK	NEXT STEPS
<b>Prepare support package</b> <ul style="list-style-type: none"><li>• Reviewed material to support next group</li></ul>	Maintain package for following group
<b>Quantify environmental indicators</b> <ul style="list-style-type: none"><li>• Compare current and proposed systems</li></ul>	Verify values
<b>Cost analysis</b>	Verify values
<b>Develop schematic feasibility plans:</b> <ul style="list-style-type: none"><li>• One island vs. multi island plans, alt. energy plan</li></ul>	Detailed comparison of options
<b>Redefine scope of contract</b> between UCB and FP for material testing	New contract adoption
<b>Outreach</b> <ul style="list-style-type: none"><li>• Find champions and sustainable partnerships</li></ul>	Identify partners
<b>Implementation</b> <ul style="list-style-type: none"><li>• Testing program</li><li>• Pilot scale plant</li></ul>	Commence field studies



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# Questions?



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